Application No. 09/889,862
Filed: July 23, 2001
TC Art Unit: 1733
Confirmation No.: 1507

THE CLAIMS

1. (Currently Amended) A method of manufacturing a bowl of thermostructural composite material formed by fiber reinforcement densified by a matrix, the method comprising making a preform constituting the fiber reinforcement by draping two-dimensional fiber plies on a former of a shape corresponding to the shape of the bowl to be made, and densifying the preform with a material constituting the matrix of the composite material,

the method further comprising:

using deformable two-dimensional fiber plies,

superposing said plies on the former,

deforming the plies so that the plies fit closely on said former by deforming without forming folds, and

bonding the superposed plies to one another by means of fibers extending transversely relative to the plies so as to obtain a one-piece bowl preform which is subsequently densified,

wherein the deformable two-dimensional fiber plies used are whole, being free from any cutouts or slots, thereby obtaining a preform for a complete bowl in one piece, and densification is performed on the complete bowl preform.

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2. (Original) A method according to claim 1, characterized in that plies are used made of a fabric formed of a plurality of unidirectional sheets superposed in different directions and bonded together so as to form deformable individual mesh loops.

3. (Original) A method according to claim 2, characterized in that plies are used made of a fabric formed of two unidirectional sheets superposed with directions that are at an angle of 45° to 60° between each other.

4. (Previously Presented) A method according to claim 2, characterized in that the unidirectional sheets are bonded to one another by knitting a thread which passes from one side of the fabric to the other.

5. (Previously Presented) A method according to claim 2, characterized in that the unidirectional sheets are bonded together by needling.

6. (Previously Presented) A method according to claim 2, characterized in that the unidirectional sheets are bonded

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together by stitching with a thread that passes from one side of the fabric to the other.

7. (Previously Presented) A method according to claim 2, characterized in that the plies are superposed by being mutually angularly offset around an axis passing through the bottom of the bowl.

8. (Original) A method according to claim 1, characterized in that deformable fiber plies are used that are formed by knitting.

9. (Previously Presented) A method according to claim 1, characterized in that plies are used formed of carbon fiber yarns that are free of surface functions.

10. (Previously Presented) A method according to claim 1, characterized in that plies are used formed of carbon fiber yarns provided with an interphase coating of pyrolytic carbon.

11. (Previously Presented) A method according to claim 1, characterized in that the superposed plies are bonded together by

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needling so as to transfer fibers taken from the plies transversely thereto.

12. (Original) A method according to claim 11, characterized in that each newly draped ply is needled onto the underlying structure.

13. (Previously Presented) A method according to claim 11, characterized in that the density of fibers transferred transversely relative to the plies is controlled throughout the thickness of the preform.

14. (Previously Presented) A method according to claim 1, characterized in that the superposed plies are bonded together by stitching.

15. (Previously Presented) A method according to claim 1, characterized in that the superposed plies are bonded together by implanting threads transversely relative to the plies.

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16. (Previously Presented) A method according to claim 1, characterized in that the preform is consolidated prior to densification.

17. (Original) A method according to claim 16, characterized in that the preform is consolidated by being impregnated with a resin, by polymerizing the resin, and by carbonizing the polymerized resin.

18. (Previously Presented) A method according to claim 1, characterized in that, prior to densification, the preform is subjected to heat treatment for dimensional stabilization and for purification at a temperature lying in the range 1600°C to 2800°C.

19. (Previously Presented) A method according to claim 1, characterized in that the preform is densified by chemical vapor infiltration.

20. (Cancelled)

21. (Currently Amended) A method according to claim 1, characterized in that ~~the deformable two-dimensional fiber plies~~

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~~used are whole, being free from cutouts or slots, so as to obtain a complete one-piece bowl preform,~~ a hole is made through the bottom of the preform prior to densification of the preform by chemical vapor infiltration, and the hole is subsequently closed by a plug.

22. (Currently Amended) A method ~~according to claim 1,~~ of manufacturing a bowl of thermostructural composite material formed by fiber reinforcement densified by a matrix, the method comprising making a preform constituting the fiber reinforcement by draping two-dimensional fiber plies on a former of a shape corresponding to the shape of the bowl to be made, and densifying the preform with a material constituting the matrix of the composite material,

the method further comprising:

using deformable two-dimensional fiber plies,

superposing said plies on the former,

deforming the plies so that the plies fit closely on said former by deforming without forming folds, and

bonding the superposed plies to one another by means of fibers extending transversely relative to the plies so as to obtain a one-piece bowl preform which is subsequently densified,

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~~characterized in that~~ wherein the deformable two-dimensional fiber plies used are whole, having a substantially central opening, the plies are superposed on the former so that their openings are in alignment, thereby obtaining a bowl preform with a hole through the bottom of the preform constituted by the aligned openings in the plies, the preform is densified by chemical vapor infiltration, and the hole is subsequently closed by a plug.

23. (Previously Presented) A method according to claim 21, characterized in that a plug of thermostructural composite material is used.

24. (Previously Presented) A method according to claim 21, characterized in that an additional step of chemical vapor infiltration is performed after the plug has been put into place in the hole formed in the bottom of the preform.

25. (Previously Presented) A method according to claim 1, characterized in that after densification, purification heat treatment is performed at a temperature lying in the range 1600°C to 2700°C.

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26. (Previously Presented) A method according to claim 1, characterized in that after densification, a coating of pyrolytic carbon is formed on the bowl.

27. (Previously Presented) A method according to claim 1, characterized in that after densification, a coating of silicon carbide is formed on the bowl.

28. (Previously Presented) A method according to claim 21, characterized in that the inside face of the bowl is lined with a protective coating.

29. (Original) A method according to claim 28, characterized in that a protective coating is used made of a thermostructural composite material.

30. (Withdrawn) A bowl of thermostructural composite material formed by fiber reinforcement densified by a matrix, in which the fiber reinforcement comprises superposed two-dimensional fiber plies, the bowl being characterized in that the fiber plies are bonded together by fibers extending transversely relative to the plies.

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31. (Withdrawn) A bowl according to claim 30, characterized in that it is a one-piece bowl and has two-dimensional reinforcing plies that are whole, without cutouts or slots.

32. (Withdrawn) A bowl according to claim 30, characterized in that the fiber plies are formed of unidirectional sheets superposed in different directions.

33. (Withdrawn) A bowl according to claim 32, characterized in that the fiber plies are made of carbon fibers.

34. (Withdrawn) A bowl according to claim 33, characterized in that the matrix is formed at least in part out of pyrolytic carbon.

35. (Withdrawn) A bowl according to claim 33, characterized in that the matrix is made at least in part out of ceramic.

36. (Withdrawn) A bowl according to claim 35, characterized in that the matrix is made at least in part out of silicon carbide.

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37. (Withdrawn) A bowl according to claim 30, characterized in that at least its inside face is coated in a layer of pyrolytic carbon.

38. (Withdrawn) A bowl according to claim 30, characterized in that at least its inside face is coated in a layer of silicon carbide.

39. (Withdrawn) The use of a bowl according to claim 30 for supporting a crucible in an installation for producing monocyrstalline silicon ingots, the use being characterized in that a protective layer is interposed between the bowl and the crucible.

40. (Withdrawn) A bowl according to claim 39, characterized in that a protective layer of thermostructural composite material is used.

41. (Previously Presented) A method according to claim 3, characterized in that the unidirectional sheets are bonded to one another by knitting a thread which passes from one side of the fabric to the other.

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42. (Previously Presented) A method according to claim 3, characterized in that the unidirectional sheets are bonded together by needling.

43. (Previously Presented) A method according to claim 3, characterized in that the unidirectional sheets are bonded together by stitching with a thread that passes from one side of the fabric to the other.

44. (Previously Presented) A method according to claim 12, characterized in that the density of fibers transferred transversely relative to the plies is controlled throughout the thickness of the preform.

45. (Previously Presented) A method according to claim 22, characterized in that a plug of thermostructural composite material is used.

46. (Withdrawn) A bowl according to claim 31, characterized in that the fiber plies are formed of unidirectional sheets superposed in different directions.

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47. (Withdrawn) A bowl according to claim 34, characterized in that the matrix is made at least in part out of ceramic.

48. (Previously Presented) A method according to claim 3, characterized in that:

the unidirectional sheets are bonded to one another by one of knitting a thread which passes from one side of the fabric to the other, by needling, or by stitching with a thread that passes from one side of the fabric to the other; and

the plies are superposed by being mutually angularly offset around an axis passing through the bottom of the bowl.

49. (Previously Presented) A method according to claim 48, characterized in that the superposed plies are bonded together by needling so as to either transfer fibers taken from the plies transversely thereto or with each newly draped ply needled onto the underlying structure; and

the density of fibers transferred transversely relative to the plies is controlled throughout the thickness of the preform.

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50. (Previously Presented) A method according to claim 48, characterized in that:

the preform is consolidated prior to densification;

the preform is consolidated by being impregnated with a resin, by polymerizing the resin, and by carbonizing the polymerized resin;

prior to densification, the preform is subjected to heat treatment for dimensional stabilization and for purification at a temperature lying in the range 1600°C to 2800°C;

the preform is densified by chemical vapor infiltration; and

the deformable two-dimensional fiber plies used are whole, being free from any cutouts or slots, thereby obtaining a preform for a complete bowl in one piece, and densification is performed on the complete bowl preform.

51. (Previously Presented) A method according to claim 50, characterized in that the deformable two-dimensional fiber plies used are whole, being free from cutouts or slots, so as to obtain a complete one-piece bowl preform, a hole is made through the bottom of the preform prior to densification of the preform by chemical vapor infiltration, and the hole is subsequently closed by a plug.

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52. (Previously Presented) A method according to claim 50, characterized in that the deformable two-dimensional fiber plies used are whole, having a substantially central opening, the plies are superposed on the former so that their openings are in alignment, thereby obtaining a bowl preform with a hole through the bottom of the preform constituted by the aligned openings in the plies, the preform is densified by chemical vapor infiltration, and the hole is subsequently closed by a plug;

a plug of thermostructural composite material is used;

an additional step of chemical vapor infiltration is performed after the plug has been put into place in the hole formed in the bottom of the preform;

after densification, purification heat treatment is performed at a temperature lying in the range 1600°C to 2700°C;

after densification, a coating of pyrolytic carbon or silicon carbide is formed on the bowl;

the inside face of the bowl is lined with a protective coating; and

a protective coating is used made of a thermostructural composite material.

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53. (Withdrawn) A bowl according to claim 36, characterized in that at least its inside face is coated in a layer of pyrolytic carbon or silicon carbide.

54. (Withdrawn) The use of a bowl according to claim 53 for supporting a crucible in an installation for producing monocyrstalline silicon ingots, the use being characterized in that a protective layer is interposed between the bowl and the crucible, and characterized in that a protective layer of thermostructural composite material is used.

55. (Previously Presented) A method according to claim 1, wherein the shape of the bowl is suitable for receiving a crucible for drawing of ingots of metal.

56. (New) A method according to claim 22, characterized in that plies are used formed of carbon fiber yarns that are free of surface functions.

57. (New) A method according to claim 22, characterized in that plies are used formed of carbon fiber yarns provided with an interphase coating of pyrolytic carbon.

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58. (New) A method according to claim 22, characterized in that the density of fibers transferred transversely relative to the plies is controlled throughout the thickness of the preform.

59. (New) A method according to claim 22, characterized in that the preform is consolidated prior to densification.

60. (New) A method according to claim 59, characterized in that the preform is consolidated by being impregnated with a resin, by polymerizing the resin, and by carbonizing the polymerized resin.

61. (New) A method according to claim 22, characterized in that, prior to densification, the preform is subjected to heat treatment for dimensional stabilization and for purification at a temperature lying in the range 1600°C to 2800°C.

62. (New) A method according to claim 22, characterized in that the preform is densified by chemical vapor infiltration.

63. (New) A method according to claim 22, characterized in that an additional step of chemical vapor infiltration is performed

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after the plug has been put into place in the hole formed in the bottom of the preform.

64. (New) A method according to claim 22, characterized in that after densification, purification heat treatment is performed at a temperature lying in the range 1600°C to 2700°C.

65. (New) A method according to claim 22, characterized in that after densification, a coating of pyrolytic carbon is formed on the bowl.

66. (New) A method according to claim 22, characterized in that after densification, a coating of silicon carbide is formed on the bowl.

67. (New) A method according to claim 22, characterized in that the inside face of the bowl is lined with a protective coating.

68. (New) A method according to claim 67, characterized in that a protective coating is used made of a thermostructural composite material.

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